Integrated Ship Defense Modeling and Simulation Pilot Program

If PMs Bring M&S Into Focus DoD-Wide, They'll See a Real Return on Investment

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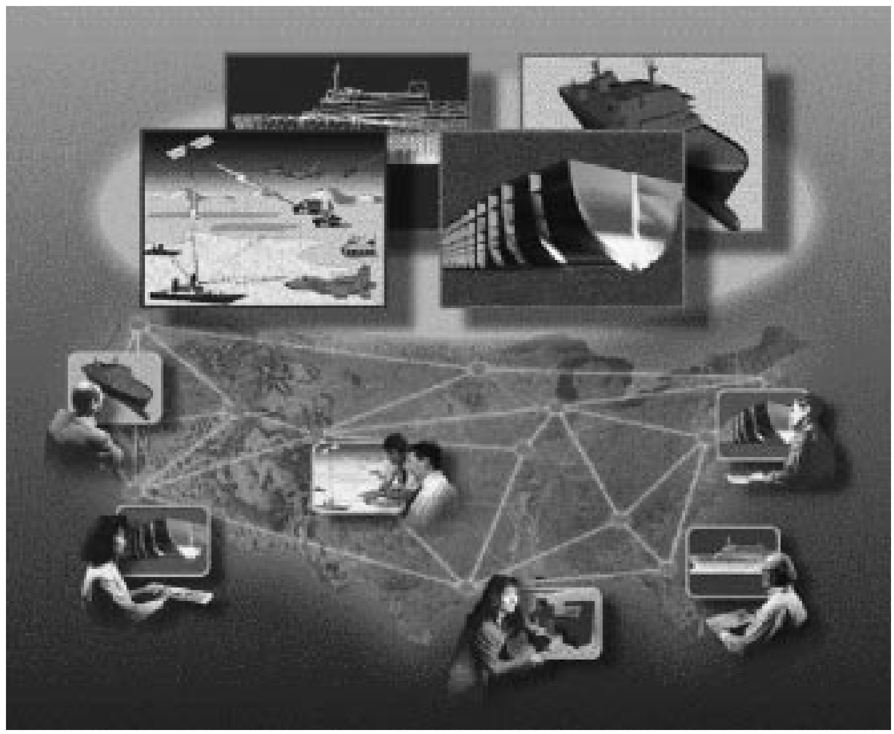

Can modeling and simulation (M&S) truly be a highway for the program manager to navigate the road to project success over the life cycle? Currently, the acquisition community is embracing Simulation Based Acquisition (SBA) initiatives, but where is the evidence that there is a payoff here? Where is the real value-added?

Traditionally, program managers navigate the life-cycle process in different ways using a variety of available tools, including M&S. So what is new here? What is this M&S revolution all about?

As a system grows throughout the engineering and development phase, SBA – when used by the engineers who are designing the system and the platform it will ride on; analysts performing trade studies and investment analyses; and testers responsible for certifying the design meets specifications – allows a conceptual model to grow in functionality and increasing specification. The end result is a well-understood, credible representation of that system, capable of augmenting developmental and operational testing. This same model can then be passed to the in-service and training community for use during deployment and Pre-Planned Product Improvements. Although the level of abstraction of the basic model may change from application, a pedigree is established based on a common system representation that becomes the standard for any application. Hence, an adaptive life-cycle tool evolves for the program manager.

Program managers then, gain the benefit of a readily available engineering model of the system that assists in the design and development process, and is reusable and interpretable, not only with other elements of the overall system, but with the entire technical and operational community. Regardless of the design agent, laboratory, field activity, or Fleet installation, the foun-

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dation exists for the operation of and interaction between the system models. When you begin to think of the flexibility SBA allows and the time it can save, the payoffs become evident. Ultimately, SBA enables us to develop, field, and support the best products to the operational community in a more cost-effective way.

Current technology can support this revolution. Now is the time for the acquisition community to be creative and integrate this technology with sound engineering practices.

Selection of the Pilot Program

In 1995, the Program Executive Office (Theater Air Defense) (PEO[TAD]) Technology Directorate proposed a set of Advanced Distributed Simulation (ADS) Pilot Programs that was, in part, prompted by the 1994 Naval Research Advisory Committee (NRAC) study. The NRAC study endorsed the use of ADS in support of the acquisition process and stated that "DoN [Department of Navy] acquisition that would provide good candidates for Distributed Simulation Based Acquisition (DSBA) are mine countermeasures, sea-based Theater Ballistic Missile Defense (TBMD), and Ship Self Defense." Based on these differing mission areas, the PEO(TAD) proposed three specific programs as potential pilot programs: Integrated Ship Defense (ISD), TBMD, and Overland Cruise Missile Defense. Ultimately, the Navy selected the ISD Pilot because it represented the most mature and current Fleet sensor/weapon system.

In May 1996, the Office of Naval Research tasked PEO(TAD) to further develop the ISD Pilot Program concept and provide a detailed program plan. A team consisting of representatives from PEO(TAD), Naval Surface Warfare Center Dahlgren, Naval Research Laboratory, Johns Hopkins University/Applied Physics Laboratory, the Mitre Corporation, and PRC Inc., provided the necessary subject matter experts for the task. Completed in September 1996, the ISD Pilot Program Plan provides the detailed technical and programmatic aspects. To generate support and solicit feedback on the proposed ISD Pilot Program, the team conducted a series of key briefings to solicit feedback, guidance, and support from key DoD/DoN senior civilian and military personnel. As a result, they gathered enough information from the following offices to transform the Pilot Program Plan into an executable program:

The sneaker net is literally the human-in-the-loop, which hand-carries the results of one model to the operator of the next. This process is labor- and time-intensive and does not capture many benefits inherent in the SSDS and QRCC.

- Office of the Secretary of Defense (OSD) Director of Research and Engineering
- OSD Director of Test Systems Engineering and Evaluation
- Assistant Secretary of the Navy for Research, Development, and Acquisition (C^4I)
- Defense Modeling and Simulation Office
- Chief of Naval Operations
- Director of Navy Test and Evaluation and Technology Requirements (N091)
- Navy Modeling and Simulation Office (N6M)

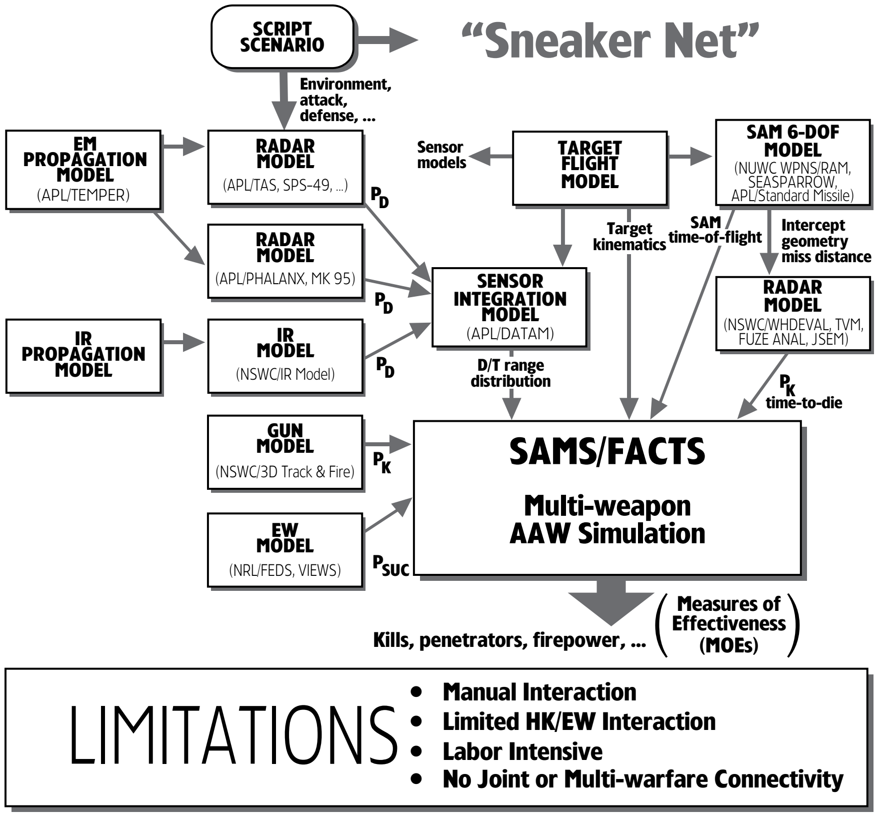
ISD Program Description

The Chief of Naval Operations approved a plan for development of a Quick Reaction Combat Capability (QRCC) to improve defenses against anti-ship cruise missiles for non-AEGIS ships, and to assure greater survivability for ships operating in harm's way.

To effectively defend against an increasingly stressing cruise missile threat, the operator requires an automated detect-through-engage capability with reduced reaction time. The operator then has the capability to associate and correlate multi-sensor data to provide a sensor-fused composite track that assures a high level of certainty in target identification and classification. Use of flexible doctrine that supports layered defense engagements provides the operator automated control of the system functions and actions. Once the system presents and displays the information such that the operators have an accurate, precise, and comprehensive picture of the tactical situation, the operator can then override, abort, or alter doctrine as necessary. Ultimately, the intent is to provide a fully automated ISD capability.

The ISD combat system provides automated detection-control-engagement by integrating existing stand-alone weapons and sensors via the Ship Self Defense System (SSDS) MK-1. Such integration involves a series of automated actions/reactions:

Figure 1. **The "Sneaker Net"**



- Existing sensors detect targets and provide track data to distributed track file processors via a Local Area Network (LAN).
- Each track file processor correlates and associates track data for use by the SSDS in Sensor Integration and Control processors, which assign and manage common track file numbers.
- The Local Command and Control processor determines target identification, classification, and appropriate action.
- The Weapon Integration and Control processors manage scheduling. Providing a layered defense that ensures the best employment of hardkill and electronic warfare (HK/EW) segments, these processors automatically determine the weapon(s) mix required to defeat the threat.

Current ISD M&S Capability

The ISD Pilot Program includes a federation of interactive hi-fidelity models built upon and from the existing family of credible, authoritative (although primarily stand-alone) ISD M&S. Separate program offices originally developed these legacy M&S to aid engineers in design, development, test and evaluation (performance prediction), and planning. With the formulation of the ISD program office and a focus on the integrated combat system operation, a need surfaced to integrate the models as well. A team of subject matter experts from various laboratories and government facilities manually integrate the models and conduct combat-system-level analysis such as Program Objectives Memorandum investment strategies; cost and operational effectiveness analyses (COEA) or Assessment of Alternatives (AOA); and selected ship-class performance capability studies. This manual integration is known as "the Sneaker Net" (Figure 1).

The sneaker net is literally the human-in-the-loop, which hand-carries the results of one model to the operator of the next. This process is labor- and time-intensive and does not capture many benefits inherent in the SSDS and QRCC. The current M&S capability, although sufficient for the applications mentioned, does not provide the level of fidelity and operational realism required for the SBA environment (i.e., common battlespace, reactive threat, jamming, realistic equipment availability, hi-fidelity modeling of Electronic Warfare/Infrared (EW/IR), Hardkill/Electronic Warfare (HK/EW), and common standardized databases that are usable by all interactive simulations).

The demand for more operationally realistic M&S capability (e.g., threats, system availability, environment, etc.), a deeper understanding of HK/EW layered defense, and a means of integrating geographically distributed engineering models and subject matter experts, highlight the need for a new approach to M&S.

ISD Technical Issues

The ISD Pilot Program addresses the shortfalls of the existing M&S capabilities (i.e., the Sneaker Net). Improvements incorporate reactive threats and operational environments to increase the realism and credibility of the results. As a first step, it builds upon an established set of existing engineering-level models with known capabilities, by linking them together via a High Level Architecture-compliant Run-Time Infrastructure (RTI). Ultimately, the ISD Pilot Program must address the following technical issues:

- Evaluate and quantify weapons and threat interaction (performance) with the environment (reactive threat, dual mode RF/IR).
- Evaluate and quantify weapons interaction (performance) with the threat.
- Evaluate and quantify sensors' interaction with threat and environment.
- Evaluate and quantify HK envelopes for probability of kill.
- Evaluate and quantify HK and EW weapons interactions and effectiveness.

- Generate accurate and repeatable system analysis data for ISD verification and isolation of problems.
- Evaluate and quantify system effectiveness using performance measures.
- Create a common-usage, controlled environment for demonstration of system modifications and standardization of threat, environment, and scenario representations.

Program managers must address and solve these technical issues through a thorough understanding of the capabilities, limitations, and interactions of a number of diverse weapons and sensors in complex land, sea, and littoral environments. To evaluate system performance, hi-fidelity, physics-based engineering simulations must reflect these complex system interactions as well as dynamic environmental effects. Consideration of these interdependencies between sensors and weapons; weapons and threats; and between sensors, weapons, and the environment, dictates a departure from the traditional isolated system and subsystem engineering analyses and simulations. In the past, program managers studied these interdependencies in the real world, through expensive exercises and testing. Regrettably, in many cases the complexity of today's weapons systems surpasses the affordability of complete testing in real-world exercises. The simulations proposed for the ISD Pilot Program will provide the capability to conduct a large part of these analyses and evaluations without expending costly ship, personnel, and test and evaluation resources, and lay the groundwork for advancing SBA initiatives.

ISD Pilot Program Overview

The goal of the ISD Pilot Program is to develop and demonstrate a comprehensive M&S capability that supports the design and evaluation of components and systems, which further support SBA initiatives. The ISD ADS Pilot Program will be conducted over a period of three years. Each phase will retain its own set of objectives; however, each phase will build on the capabilities demonstrated in the preceding phase. Figure 2 shows the three phases of the program and the evolving capabilities. The goal is to increase the simulation set and proceed toward the eventual implementation of the superset of simulations. A brief description of each phase follows.

Phase I

The development team intended that this initial phase provide a benchmarking opportunity in the development of ISD Federation. Accordingly, the system designers, modelers, and testers will be addressing the complex issues inherent to test and evaluation. Of particular interest is the ability to perform HK/EW integrated modeling in a distributed environment using a High Level Architecture-compliant RTI. For this reason, the approach is conservative and is tailored to achieve the greatest capability in a one-year time period. This time period will still permit the development team to gain the experience needed to accomplish more complex configurations in subsequent phases. To minimize risks, the simulations will be developed at the developer's site. The integration, however, will be accomplished in a single laboratory, with the simulations interconnected via RTI, but using a LAN. The products of Phase I are —

- first-time, hi-fidelity detect-through-engage simulation capability;
- hi-fidelity, integrated HK/EW assessment capability;
- threat reactive-common to all combat system elements;
- contribution to Joint Synthetic Test and Evaluation battlespace;
- established foundation for Phases II and III;
- PEO(TAD) established as a beta test site for Defense Modeling and Simulation Office RTI; and
- verification and validation of federation.

Figure 3 depicts the architecture for Phase I development.

Phase II

The intent in Phase II is to use the experience gained in Phase I to greatly increase the capability of the federation through the incorporation of additional federates. This com-

Figure 2. **Evolving Capabilities**

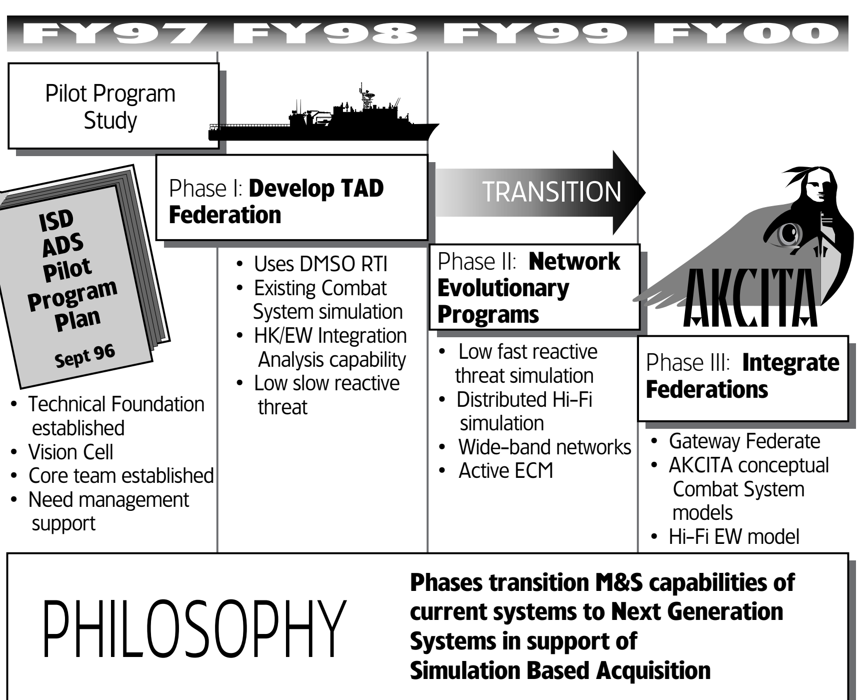
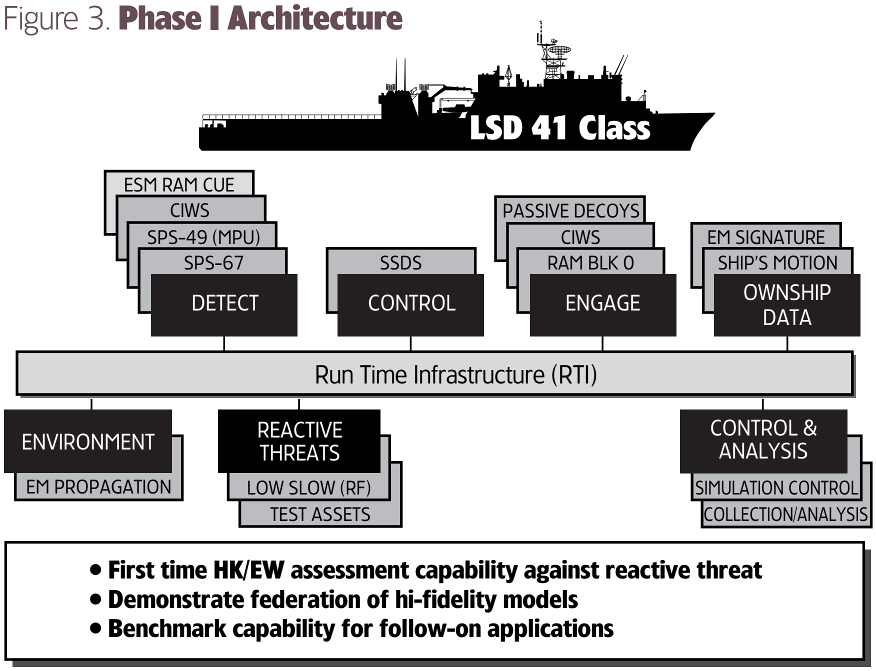


Figure 3. **Phase I Architecture**



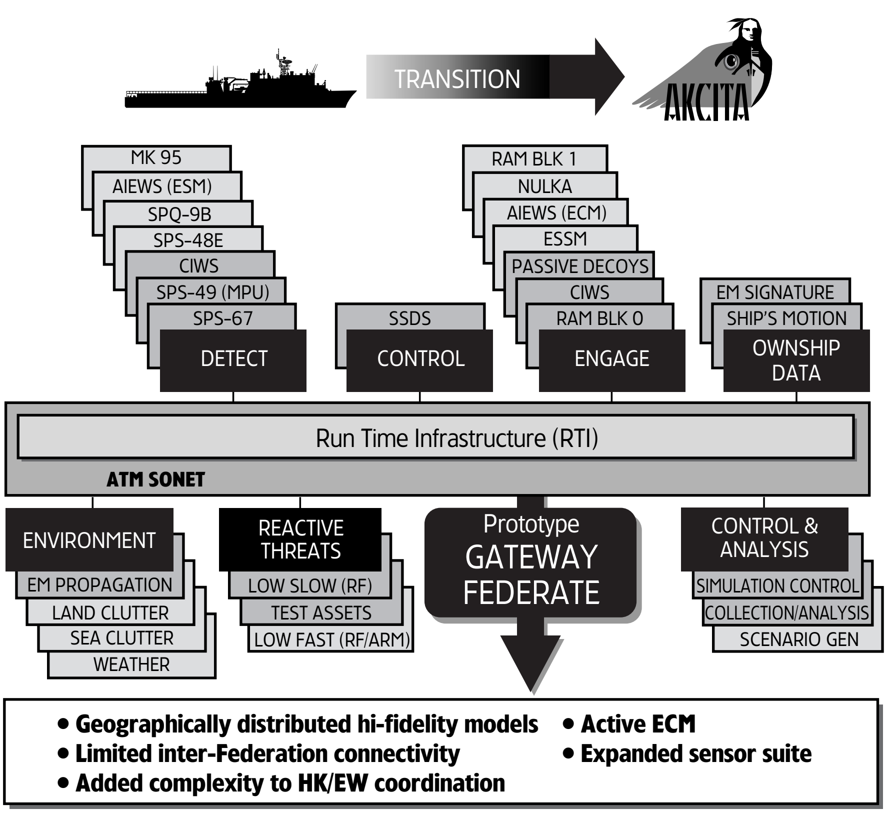
plexity will enable a close examination of sensor integration and will permit a systematic approach to the investigation of HK/EW coordination. Models involved in this phase will reside at the developer's site and will be interconnected, through the RTI, via a geographically distributed network.

Additional reactive threats will be added in this phase. The intent is to add threats whose performance can stress the capabilities of the ISD combat system. In this way the federation can be used to explore reaction times of different combat system configurations to stressing situations. This will also permit an evaluation of the federation and its capability to simulate real-time operation. The products of Phase II are —

- active electronic attack assessment;
- realistic representation of operational environment;
- geographically distributed simulation using Asynchronous Transfer Mode/Sonet Network;
- network technology that provides feasibility of a re-use tool;
- verification and validation of federation; and
- additional threat families represented.

Figure 4 depicts the architecture for Phase II development.

Figure 4. **Phase II Architecture**



Phase III

The intent of Phase III is to produce a federation that provides a capability to model conceptual systems of the next generation combat system — Akcita. This will enable the federation to support SBA initiatives for future acquisition programs.

To provide a realistic operational environment, this phase will complete the addition of propagation, clutter, and weather models to achieve a dynamic multispectral environment. This will enable the examination of both Radio Frequency (RF) and Infrared (IR) threats in a stressing environment. To provide detection of these dual-mode threats, this phase also adds an IR sensor.

The Gateway Federate will be employed and tested in this phase, enabling communication and interaction between two federations of differing levels of fidelity and resolution. The intent is to link the ISD Federation to the Joint Countermine Operational Simulation (JCOS) Federation to simulate a multi-warfare exercise.

This would permit inter-federation communications between a federation operating with engineering-level simulations and a federation operating at an engagement simulation level (i.e., lower fidelity). Phase III products include —

- IR sensor, environment, and threat modeling;
- conceptual ship and combat system models;
- advanced threat models (full complement of ISD threat representative models);
- advancement of SBA initiatives through multi-fidelity simulation;
- inter-federation linking (Gateway Federate); and
- verification and validation of federation.

Figure 5 depicts the architecture for Phase III development.

Value-Added and Support to Acquisition Program Manager

The tools resulting from completion of the Pilot Program have the potential to enhance the system acquisition process by adding value in the following areas:

- **AOA.** The federation of ISD analytical models can be used to determine operational effectiveness against specified threats as part of an AOA Study.
- **Mission.** As a means of developing a Requirements Definition, the simulations provide a means for quantitative evaluation of measures of effectiveness and performance prior to verifying system requirements.
- **System Engineering.** The Interactive ISD Federation will provide a mechanism for developing and exercising a prototype system in a simulated environment. This will, in effect, create a laboratory for trying out a design or an engineering change proposal, before its approval as an engineering requirement.
- **Design and Analysis.** The simulations provide a mechanism for the collection of performance data as a basis for design of system modifications. A significant feature is the ability to conduct repeatable test conditions, and the capability to parametrically vary the conditions in a controlled manner.
- **Testing and Evaluation.** The ISD Federation will provide a virtual simulation capability that will enhance test and evaluation efforts by providing better-designed systems as a result of testing earlier in the development phase. A wider scope of testing may be possible for some systems, especially those that require large scenarios of costly test services, such as multiple aircraft flyovers or test targets and associated range services.
- **Doctrine and Tactics.** The ISD Federation will provide a method to evaluate the tactics and doctrine by exercising the prototype ISDS human-machine interface in conjunction with the simulated sensors and weapons.

Bringing M&S Into Focus

The key issue for program managers to understand is that as M&S is brought into focus DoD-wide, the real return on investment will be realized. Because of declining budgets and technically advanced systems, we can no longer continue business as usual and expect to field the same quality systems. We must rely more on the benefits M&S can provide, but first we need to lay the foundation that makes that possible. Program managers need to have a high degree of confidence in their models and the subject matter experts to operate them. The key is to get started, take a small piece of the problems, and work from there. The momentum of success and opportunity to leverage from other's work will carry the effort forward. Every effort toward this goal helps by bringing M&S into clear focus for the acquisition community.

Figure 5. **Phase III Architecture**